THURSDAY, APRIL 18, 1878

THE COMING TOTAL SOLAR ECLIPSE

THERE is no doubt whatever that the eclipse which will sweep over the United States next July will be observed as no eclipse has ever been observed before. The wealth of men, the wealth of instruments, and the wealth of skill in all matters astronomical, already accumulated there, makes us Old Country people almost gasp when we try to picture to ourselves what the golden age will be like there, when already they are so far ahead of us in so many particulars.

Draper, Hall, Harkness, Holden, Langley, Newcomb, Peters, Peirce, Pickering, Rutherfurd, Trouvelot, and last, but not least, Young, are the names that at once run easily off the pen to form a skeleton list, capable of considerable expansion with a little thought, when one thinks of the men who will be there. One knows too that all the enthusiasm of devoted students and all the appliances of modern science—appliances in the creation of which many of those named have borne so noble a part—will not be lacking. So that we may be sure that not only all old methods but all possible new ones will be tried to make this year one destined to be memorable in the annals of science side by side with 1706, 1851, 1860, and other later years.

Thank Heaven, too, there is no necessity that the thankless task of organising an "Eclipse Expedition" from this country should fall on any unfortunate individual, among other reasons because—and this is a very hopeful sign of increasing general interest taken in scientific work—Messrs. Ismay, Imray and Co., the owners of the White Star Line, have expressed in the warmest manner their desire to aid English observers by a considerable reduction of fares, and the directors of the Pennsylvanian Railway Company, as the readers of NATURE have already been made aware, have done the like in the case of observers coming from Europe in their individual capacity.[1]

The progress in that branch of knowledge which requires the aid of eclipse observations has been so rapid during the last few years that the eclipse of 1868, though it happened only ten years ago, seems to be as far removed from the present as the Middle Ages are in regard to many other branches of culture. The work done by the spectroscope since that year, when in the hands of Janssen, Pogson, Herschel, and others, it added so enormously to our knowledge, has gradually covered larger and larger ground, and each successive eclipse in 1869, 1870, 1871 and 1875, has seen some variations in its use, so that its employment has proved the most novel, if not the most powerful, side of the attack.

Young's work of 1869 will no doubt form the key-note of much that will be done this year so far as the coronal atmosphere is concerned. It will be remembered that Young in 1869 observed a continuous spectrum, while Janssen in 1871 observed a non-continuous one, for he recorded the presence of the more prominent Fraunhofer lines, notably D. This positive observation from so distinguished an observer demands attention, not only on its own account, but because of the question which hangs upon it, which is this: Does the corona reflect solar light to us or does it not, and if it does, *where* are those particles which thus act as reflectors? On this point the photographs taken in Siam in 1875 are silent, as the method employed was not intended to discriminate between a continuous and a discontinuous spectrum.

But although this point remains, how greatly has the ground been cleared since 1869. That wonderful line, "1474," is more familiar to us now! and yet there has been almost a chapter of accidents about it. In the first place, with regard to this line above all others, there appears to be a mistake in Angström's map; the solar line at 1474 is not due to iron at all; with the most powerful arc there is no iron line to be seen there. Then Secchi attributed it to hydrogen, though I am not aware on what evidence. But whatever be its origin, the fact remains that we now know by its means that the solar hydrogen is traversed and enwrapped by the substance which gives rise to the line to an enormous height, so that it forms the highest portion of the atmosphere which is hot enough to render its presence manifest to us by spectral lines. Here, so far as I know, only one point of difference remains. In 1871 I most distinctly saw the line trumpet-shaped, that is, with the base broadening as the spectrum of the photosphere was reached, while Janssen saw it stopping short of the spectrum of the photosphere. The importance of this point is that supposing one of us to be mistaken and one or other observation to represent a *constant* condition, then, if the line broadens downwards till the sun is reached we are dealing with a gas lighter than hydrogen, capable of existing at a high temperature, which thins out as the other gases and vapours do in consequence of its vapour density being below that of hydrogen; or, on the other hand, if the line stops short as a constant condition, it represents a substance which is probably dissociated at the lower levels, and is therefore probably a compound gas; and then the question arises whether it has not hydrogen as one of its constituents.

Perhaps I may conveniently refer to a paper of mine which was read at the Royal Society last Thursday in this connection, because it may be that the solar regions most worthy of the closest study at the present time are precisely these higher reaches of the sun's atmosphere. There is little doubt, I think, that around the sun's visible atmosphere matter exists at a temperature low enough not to give us its autobiography in the bright line manner, and there is evidence that matter existing under such conditions, absorbing as it must do some of the sun's light, will, if it remains elemental, give us an absorption of the fluted kind, or again will absorb only in the blue or ultra-violet region.

Now the more the chemistry of the reversing lower layer of the sun's atmosphere—that in which the upper level of the photosphere is bathed—is examined the more metallic is it found to be. For instance, my own work has enabled me to trace with more or less certainty eighteen metallic elements,[1] in addition to those recorded

[1] In fact Messrs. Ismay, Imray and Co. have just announced that they will take properly certified observers and bring them home again for the sum of 20*l.*, which is rather less than 1st class single fare; so that English observers will be carried to Denver or the Rocky Mountains and back again for the sum of 34*l.*

[1] These are strontium, lead, cadmium, potassium, cerium, uranium, vanadium, palladium, molybdenum, indium, lithium, rubidium, cæsium, bismuth, tin, lanthanum, glucinum, and yttrium or erbium.

by previous observers; but of metalloids in this region I have traced none. The persistency with which metal after metal revealed itself to the exclusion of the metalloids led me to throw out the idea some time ago, that perhaps the metalloids lay as a whole above the metals, and shortly afterwards I obtained evidence which seemed to me of a very satisfactory nature as to the existence of carbon, its presence in the sun's atmosphere being rendered probable by fluted bands, and not by lines. There were two points, however, which remained to be settled before the matter could be considered to be placed beyond all doubt.

The first was to establish that the fluted bands generally present in the spectrum of the electric arc, as photographed, which bands vary very considerably in strength according to the volatility of the metal under experiment, were really bands of carbon—a point denied by Angström and Thalèn.

This point I have settled by two photographs, in which the carbon bands remain the same, though one spectrum is that of carbon in air, the other of carbon in dry chlorine.

The next point was to insure accuracy by the most positive evidence that there was absolutely no shift in the carbon bands. Such a shift is produced when the part of the arc photographed is not perfectly in the prolongation of the axis of the collimator of the spectroscope. Its effect is to throw the lines of iron, for instance, a little to the right or a little to the left of the Fraunhofer lines with which they really correspond.

I have now obtained a photograph which supplies such evidence. There are metallic lines close to the carbon bands which are prolongations of Fraunhofer's lines, while the lines which I have already mapped at W. L., 39·27 and 39·295, in the spectrum of iron, are also absolute prolongations. Therefore there is no shift in the carbon flutings, and the individual members of the fluted spectra in the brightest portion are absolute prolongations of a fine series of Fraunhofer lines in the ultra-violet.

Now how does this connect itself with observations of the upper parts of the solar atmosphere?

Angström has already shown that the true carbon *lines* which we get when a coil and jar are employed are not reversed in the spectrum of the sun, and I have already shown that the calcium spectrum in the sun is similar to the spectrum obtained when the spark, and not the arc, is employed. Accompanying the change from a high to a higher temperature, there is a change in the intensity of the lines—some thicken, others become thinner. We can only match the relative thickness of the solar calcium lines by employing a very powerful coil and jar—so powerful, indeed, that the lines, and not the flutings, of carbon would be visible in the spark given by it. It is fair then to say that if carbon were present with the calcium *in the sun's reversing layer*, we should get the lines of carbon when we get the calcium lines appearing as they do.

As we do not get this evidence, we are driven to the conclusion that the carbon vapour exists not only in a more complicated molecular condition (as is evinced by the flutings) than the metallic vapours in the sun's atmosphere, but at a lower temperature. It must, therefore, exist *above the chromosphere*, that is, in a region of lower temperature. Lower pressure, again, is indicated by the feeble reversal, so that everything points to a high level.

The question is, will this region be recognised during the coming eclipse?

Coming down lower we reach a level better known, and of which, perhaps, the interest during the eclipse will now be less, if we except the possibilities opened out to us by photography. One good photograph of the lines visible in the lower chromosphere will be of incalculable value. Attempts may be made on the cusps just before and after totality, and if only one of these succeeds we shall have the ordinary solar spectrum as a scale. If good pictures near H can be secured, enough information now exists for that region to enable us to determine the chemical origin of the bright lines photographed. These remarks apply to attempts made with spectroscopes furnished with slits in the ordinary way; there is little doubt, however, that the method utilised for the Siam eclipse in 1875, the method suggested by Prof. Young and myself for the Indian Eclipse of 1871, will also be taken advantage of; here the chromosphere itself becomes the slit. A dispersed series of spectral images of the thing itself, instead of the spectrum of a part of the image of it focussed on a slit is obtained, the position of each image in the spectrum enabling its chemical origin to be ascertained if only a comparison spectrum can be secured at the same time.

In 1875, in the expedition to Siam, the photographs of this nature were obtained by means of a prism, and the results obtained by that expedition led me to think that, possibly, this method of using the coronal atmosphere as a circular slit might be applied under very favourable conditions if the prism, or train of prisms, hitherto employed, were replaced by a reflection grating, with which the generosity of Mr. Rutherford has made many of us familiar, for the simple reason that while a prism only gives us one spectrum, a brilliant grating placed at right angles to an incident beam gives us spectra of different orders, so-called, on each side of the line, perpendicular to its surface. Of these two or three are bright enough to be utilised on each side, so that we can get six in all.

To test this notion I made the following experiment with a grating given to me by Mr. Rutherfurd. This magnificent instrument contains 17,280 lines to the inch, ruled on glass and silvered; its brilliancy is remarkable.

In front of the condenser of an electric lamp adjusted to throw a parallel beam, I placed a circular aperture, cut in cardboard, forming a ring some 2 inches in interior diameter, the breadth of the ring being about $\frac{1}{8}$ inch. This was intended to represent the chromosphere, and formed my artificial eclipse.

At some distance from the lamp I mounted a $3\frac{3}{4}$ inch Cooke telescope. Some distance short of the focus I placed the grating; the spectrum of the circular slit, illuminated by sodium vapour and carbon vapour was photographed for the first, second, and third orders on one side. The third order spectrum, showing the exquisite rings due to the carbon vapour flutings, was produced in forty-two seconds. The first order spectrum, obtained in the same period of time, was very much over-exposed. It is, therefore, I think, not expecting too much that we

should be able to take a photograph of the eclipse, in the third order, in two minutes. Similarly, we may hope for a photograph of the second order in two minutes, and it is, I think, highly probable also that a photograph of the first order may be obtained in one minute. To make assurance doubly sure, the whole of the totality may be used during the coming eclipse, but if there be several such attempts made it will certainly be worth while to try what a shorter exposure will do.

Now, by mounting photographic plates on both sides of the axis, one solidly mounted equatorial of short focal length may enable us to obtain several such photographs, with varying lengths of exposure. I insist upon the solidity of the mounting because, if any one plate is to be exposed during the whole of totality, the instrument must not be violently disturbed or shaken while the eclipse is going on. I think, however, it is quite possible to obtain more than one photograph of the lower order spectra without any such disturbance in this way. The same plate may be made to record three, or even four, exposures in the case of the first order in an eclipse of four minutes' duration, by merely raising or lowering it after a given time, by means of a rapid screw or other equivalent contrivance, so that a fresh portion of the same plate may be exposed. Similarly, the plates on which the spectra of the second order are to be recorded may be made to perform double duty.

If one equatorial thus mounted were to be devoted to each quadrant of the coronal atmosphere, it is certain, I think, that most important results would be obtained.

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(*To be continued.*)

GIGANTIC LAND-TORTOISES

Gigantic Land-Tortoises, Living and Extinct, in the Collection of the British Museum. By A. C. L. G. Günther, M.A., M.D., F.R.S. Keeper of the Department of Zoology. (London: Printed by Order of the Trustees, 1877.)

THE recent and extinct gigantic land-tortoises in the collection of the British Museum has just received at the hands of Mr. A. C. L. G. Günther, Keeper of the Department of Zoology, an elaborate and exhaustive memoir and history. As early as 1872 Dr. Günther had made much progress in the elucidation of their structure, but in 1874 the osteology of the Mascarene tortoises had still more engaged his attention. Again in 1877 new matter arising from fresh materials imported into England from the Aldabra group of islands, Mauritius, Rodriguez, and the Albemarle and Abingdon Islands, enabled Günther to complete his memoir upon these gigantic land-tortoises, recent and fossil.

This important volume contains a description of the races of the Aldabra group, the extinct races of the Mascarene group (Mauritius and Rodriguez), and lastly, the Galapagos Islands races. Dr. Günther, at p. 10, gives a synopsis of the fossil and living gigantic land-tortoises. He bases his classification upon the presence or absence of the nuchal plate—frontal portion of the skull—condition of the pelvis as to nature of the symphysial bridge, and whether the gular plate is single or double. The Aldabra tortoises, or those of the Aldabra Islands, fall under the first group, or those with the nuchal plate present, gular plate double, and frontal portion of skull convex and with the pelvis having a narrow symphysial bridge. Four species of Testudo, all living, occur in the Aldabra group.

The second group, embracing the Mascarene and Galapagos tortoises, possess no nuchal plate; the symphysial bridge is broad, and the frontal portion of the skull is flat. The Mascarene species, four in number, are all extinct, and are found by Günther to have a single gular plate and short sternum, whereas the Galapagos tortoises have a double gular plate and rather large sternum, and all but one species (*Testudo ephippium*), from Indefatigable Island, are living.

These deductions arrived at by Dr. Günther after years of long and patient labour, greatly add to our knowledge of the structure of the Testudinæ greatly removed in space; he not only shows that the Aldabra species have definite and almost individualised structure, but that they are entirely different species from their nearest or Mascarene neighbours, a great fact in the distribution of life, over an area once continuous land, but now known to be one of depression, and yet geographically contiguous, the Island of Madagascar only separating them. Here, however, we have not a wide distribution in space, and yet no species seems common to the Mascarene and Aldabra Testudinæ—the living races of the Aldabra group being entirely different from the extinct races of the Mascarenes. Dr. Günther endeavours to show that in the absence of direct genetic relationship between the tortoises of the Galapagos Islands and the Mascarenes, that some "terrestrial tortoises" were transported through some agency ("stream or current") from the American continent to the Galapagos—and similarly that those of Madagascar or Africa migrated in a similar manner to the Mascarenes. The origin and geographical distribution of species especially terrestrial is always of the highest interest to earnest students of life in its various phases. The history and origin of species, and their distribution, is perhaps one of the most difficult problems now engaging the minds of naturalists, and Gunther refers to the reappearance of the "Indian, Mascarene, and Aldabra gigantic land-tortoises in the Galapagos," as one of these—not, he says, in "typical singularity, but with all the principal secondary modifications reproduced." The greater extension of this large Chelonian type at a former geological epoch seems manifest, when we find remains at Malta corresponding with those of the Galapagos tortoises, and the close affinity between the Galapagos and the Aldabra and Mascarene species, although separated by so vast a distance; we must grant a continuity of land over the region now covered by the Pacific, and which for ages has undergone, and is still undergoing depression. No one can doubt or fail to see the great changes that have taken place in the physical geography of South Africa, whose attenuation towards the south and eastern coasts is due to depression, thus causing the isolation of Madagascar, the Mascarene Islands, and the Seychelles, such severance and island making, through causes long-continued and not equally the same areally in equal times, has produced that specialised or peculiar fauna for which many of